7: Light-atom interaction

Mittwoch, 14. Dezember 2022 16:10

(7.1) $i\hbar \frac{d\psi}{dt} = H\psi$

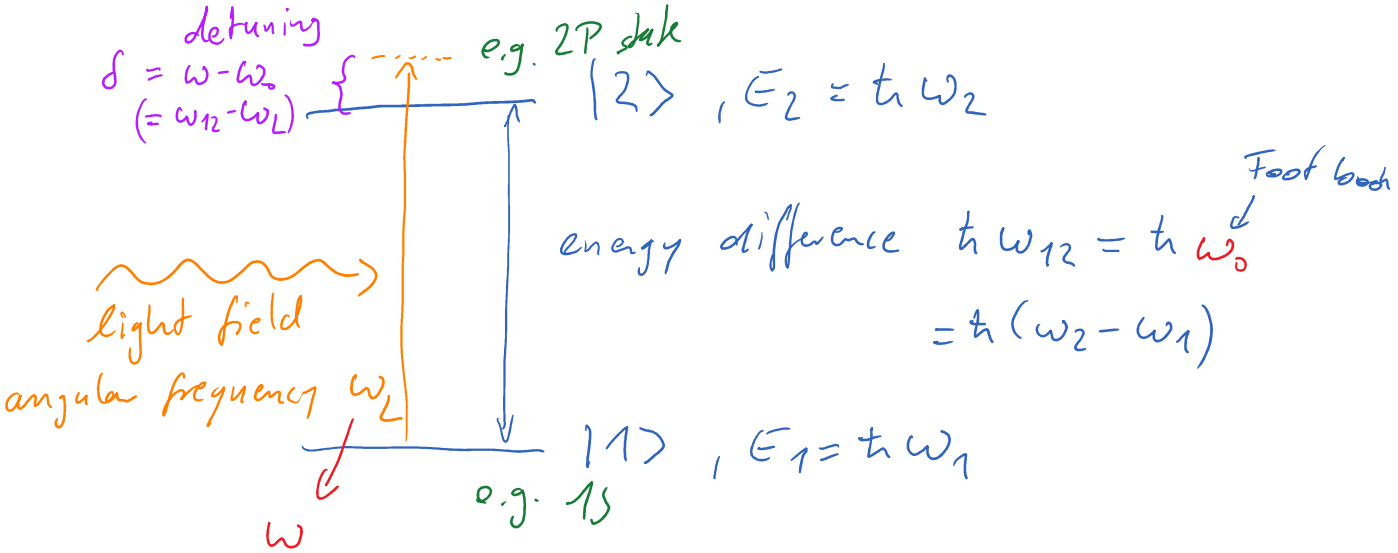
describes the time evolution of a system with wave function ψ under some interaction Hamiltonian

$\Rightarrow$ only <u>coherent</u> processes can be described!

But incoherent processes = very important!

↳ spontaneous decay!

atom as a 2-level system + interaction with light



S.E.

(7.5) $\psi(\vec{r},t) = c_1 \psi_1(\vec{r})\, e^{-\frac{iE_1 t}{\hbar}} + c_2 \psi_2(\vec{r})\, e^{-\frac{iE_2 t}{\hbar}}$

(7.2+7.8) $H = H_0 + H_I$

$H_I = e\vec{r}\,\vec{E}_0 \cos(\omega t)$

Dipole op. — electric field of the light field

(7.9) 10 interaction with light field changes the coefficients $c_i(t)$

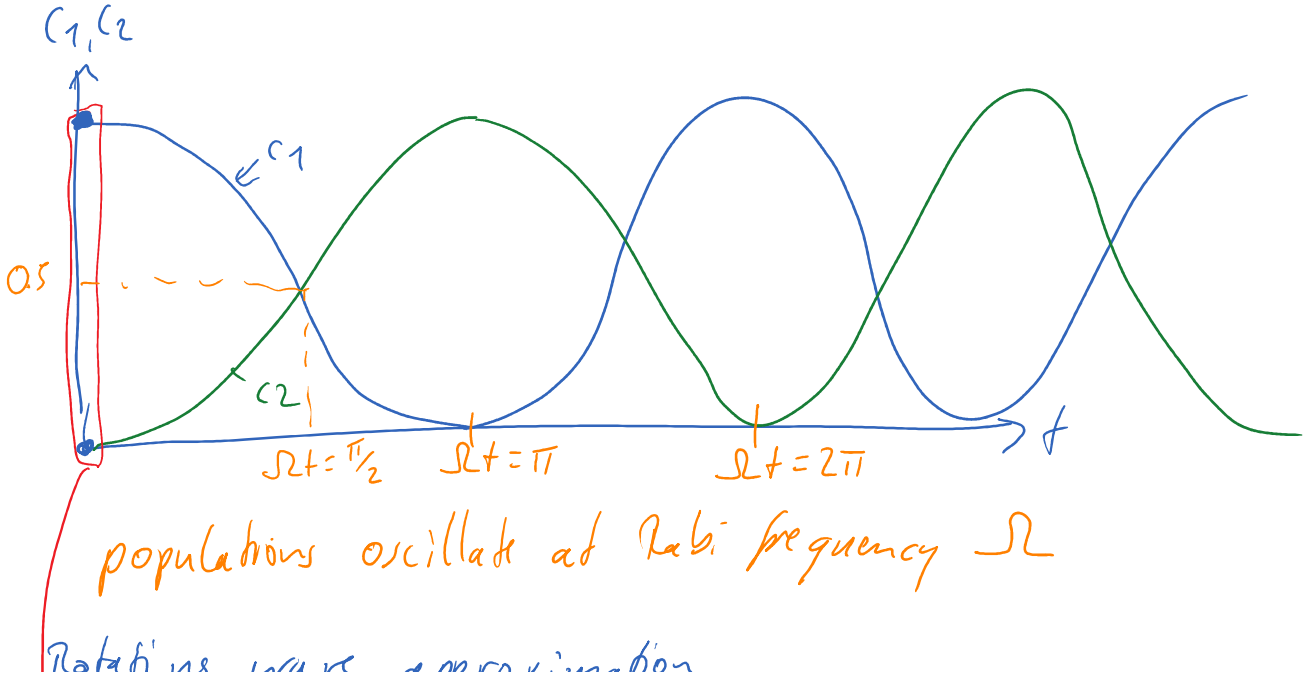
$$i\dot{c}_1 = \Omega \cos\omega t\, e^{-i\omega_0 t} c_2$$
$$i\dot{c}_2 = \Omega^* \cos\omega t\, e^{+i\omega_0 t} c_1$$

$$\omega_0 = \frac{E_2 - E_1}{\hbar}$$

Rabi frequency Ω (usually this Rabi frequency is called Ω_0)

for 0 detuning $\hat{=}$ $\omega_{light} = \omega_{atom}$ ↑ on resonance

e.g. $t=0$ $c_1 = 1$, $c_2 = 0$ } atom is g.s.



populations oscillate at Rabi frequency Ω

7.1.2 Rotating wave approximation

7.1.2. Rotating wave approximation

(7.14) $c_1(t) = 1$

$$c_2(t) = \frac{\Omega^*}{2}\left\{\frac{1-e^{i(\omega_0+\omega)t}}{\omega_0+\omega} + \frac{1-e^{i(\omega_0-\omega)t}}{\omega_0-\omega}\right\}$$

oscillates too quickly → averages

large

Taylor expanded for small $c_2 \ll 1$

$\omega_0 - \omega$: 1 GHz

$\omega_0 + \omega \approx 2 \times \omega_0 \approx 1000\ THz$

typical resonance spectrum in laser spectroscopy